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VOLKHOVSTROI HYDROELECTRIC PLANT NEAR LENINGRAD

(Figures referred to herein are not reproduced.)

Summary:

The Volkhovstroi hydroelectric power plant which began operations in 1927 supplies power to Leningrad (St Petersburg), one of the most important centers of the Russian processing industry. It has an 80,000-horsepower installed capacity, a 130-kilometer overhead line and several transformer stations. At this time (1928) it is the largest power plant and power-distribution installation in the Soviet Union. A description of the structural and electrical parts of the installation is given.

Industry concentrated in Leningrad is exclusively dependent on coal imported from foreign countries. Russian coal from the Donets Basin is unable to compete (for the market) because of the long transportation route involved. The total power requirements of industry in the Leningrad area amounted to:

1916	600 million kwh
1926	312
1936	456
1937	616

A plan had been made, even before World War I, to eliminate the dependence on foreign coal and to procure power from hydroelectric plants. Attention was drawn to the Volkhov River while the various possibilities for utilizing water power were under consideration. This 223-kilometer river has its source in Lake Ilmen and flows into Lake Ladoga, which is not far from Leningrad. The volume of water averages 367.1 cubic meters per second with a maximum of 1,380 cubic meters per second. Consequently it is subject to great fluctuations. One hundred-thirty kilometers

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east of Leningrad the river flows through a calcareous slate deposit. Here rapids are formed with a 9.5-meter gradient over a distance of about 10 kilometers.

The importation of coal to Petersburg was paralyzed during the war and the industrial power supply was blocked. This led to the decision to erect a power plant below the rapids. The plant was to have an installed capacity of 80,000 horsepower, an average yearly capacity of 40,000 horsepower, and would be able to produce 225 million kilowatt-hours and save 260,000 tons of coal per year. Construction was not started until the end of 1921 and the plant began operation in 1927. The plant merits general interest not only because it is at this time the largest power plant in Russia, but also because of the varied character of the construction and building methods employed in its construction. The hydraulic phase of the installation was constructed exclusively by Russian labor, but foreign plants as well as Russian ones participated in building the electrical equipment. However, the plans and the direction of the construction were in the hands of Russian engineers. The ASEA, Wiquist and Holm, and Vickers delivered equipment on a large scale.

The Hydraulic Installation

The location of individual structure can be seen in Figure 1.

The dam and the power-plant building form an obtuse angle. A wall to protect the power plant from floating ice is located in front of the power plant. A one-chamber lock lies to the right of the power plant. There is a high water spillway between the lock and the power plant. The plant used 700 cubic meters of water per second when all turbines are in operation, while the river volume is 2,400 cubic meters at high water. With the water flowing over the dam reaching an approximate height of two meters, the dam can let off only 1,300 cubic meters per second. The rest, i.e., 2,400 - 1,300 - 700 = 400 cubic meters per second, has to be carried off by the high water spillway.

A 120,000-volt, 130-kilometer overhead line to Leningrad was built simultaneously with these installations; a transformer station, secondary transformer stations, and a cable circuit connecting these transformer stations were set up in the city proper.

The dam is built of solid concrete as a solid overflow dam (Figure 2).

Particular attention was devoted to developing the face of the dam crest which has the shape of the overflowing water, and to the development of the protecting apron. The lower part of the protecting apron is shaped like a trough elevated at the end, so that a basin can only be formed outside the dam area. The lower part of the face and protecting apron are lined with granite stone, while the foot of the fall is of concrete without lining. The foot of the fall is anchored in the river bed by iron stays. The dam is 310 meters long, 17.67 meters high and 39.2 meters wide. The dam is made up of 26 parts each 7.5-15 meters long. These parts are connected by elastic iron panels set in asphalt-lined shafts. The purpose of this is to protect the dam against the effects of temperature changes.

The body of the dam has a one-meter layer of cement 1:4 on the outside. The inner part consists of a concrete mixture 1:6. In addition to this, the area near the bottom is plastered with a 5-centimeter layer of concrete. The dam rests on ten caissons of ferroconcrete. These

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caissons are 1.93 meters high and have a ground area of 21,857 square meters. On top of the caissons there are casings for the construction of the masonry. The 400-ton caissons were assembled on wooden frames. They were then brought to the location by floating cranes, let down with the help of compressed air, and lined. The masonry of the roof was taken care of in the usual manner and at the same time. The spaces intervening between caisson pillars were shut off by two plates, the water was pumped off, and then the spaces were lined as in an open mine pit. Either iron plates or slabs of ferroconcrete were used on the upper water side. Plates consisting of wooden slabs set in a ferroconcrete framework sufficed for the lower water side.

The power plant structure is divided into three parts: the central structure which houses the machine room, the control room and the transformer room; the "lower island" where the workshop, the administration building and the store rooms are located; and the "central island" where the testing rooms and the battery room are to be found. The foundation of the central structure consists of concrete mass 142 meters long. This is penetrated by spiral chambers and turbine pipes. The inlet pipes have a diameter of 13.5 meters but in spite of this width had to be laid very deep, i.e. 6 meters beneath the river bottom.

A 1.5 kilometer branch of the overhead line leads to the "Red October" power plant which is 20 kilometers from Leningrad. This delivers power to a transformer station set up as an open air plant (100,000/6,000 volts).

In Leningrad, the overhead line delivers to a transformer station (100,000/35,000 volts) which has nine single-phase transformers comprising three groups of 33,000 kilovolt-amperes each. One of these groups serves as a reserve. There are also transformers in the transformer station to transform from 100 kilovolts to 6.3 kilovolts for the requirements of adjacent parts of the city. All the electrical equipment of the transformer station comes from the AEG. Transformers and oil switches are in the first story of the high-tension-plant building; the inlets of the overhead line, the disconnecting switches and the impedance coils are in the second story. The oil switches, the protective apparatus, and the voltage transformers are in the first story of the low tension plant; the current-collecting rails are in the second story. The control room is located between the two buildings.

The current is fed from the transformer station to secondary transformer stations by 35 kilovolt cables. The cables were laid in the shape of two semicircles, 73 kilometers in length, which surround the city of Leningrad on the north and south. A total of 69.3 kilometers of cable was laid, 2.6 kilometers under water. They are rotary current cables, 3 x 120 square millimeters taking a normal load of 285 amperes with control filaments (Lynro protection). Cable connections are mounted on ferroconcrete plates covered with ferroconcrete caps. All cables come from the Leningrad cable plant.

The 35 kilovolts of the cable net are transformed in seven secondary transformer plants to 6,600 or 3,300 volts, the voltage of the power plants existing in Leningrad. Three of these secondary transformer stations are installed in the buildings of already existing power plants. Buildings were erected for four transformer stations. The transformer stations have two or three transformers of 6,000 kilovolt-amperes each. Four of the transformer stations were set up for synchronous-phase conversion to improve the capacity factor. All trans-

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formers of the secondary transformer stations were procured from Russian plants. The control installations and phase converters are from Siemens.

It is not possible to give a definite statement on the cost of the entire construction since inflation prevailed in Russia when it was started. However the building administration gives the figure of 90 million prewar rubles (about 190 million gold marks) as the total actual cost of the construction. This amount was divided as follows: 15 million for the lock and canals; 56 million for the power plant, 7 million for the overhead line, 5 million for the transformer station, 7 million for the cable net and secondary transformer stations.

It was possible to put the plant into partial operation in the middle of 1927. It was to furnish the basic power supply to the Leningrad industry. Construction covered a period of five years but the first years could not be used to an advantage because of the after-effects of the Revolution and inflation.

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